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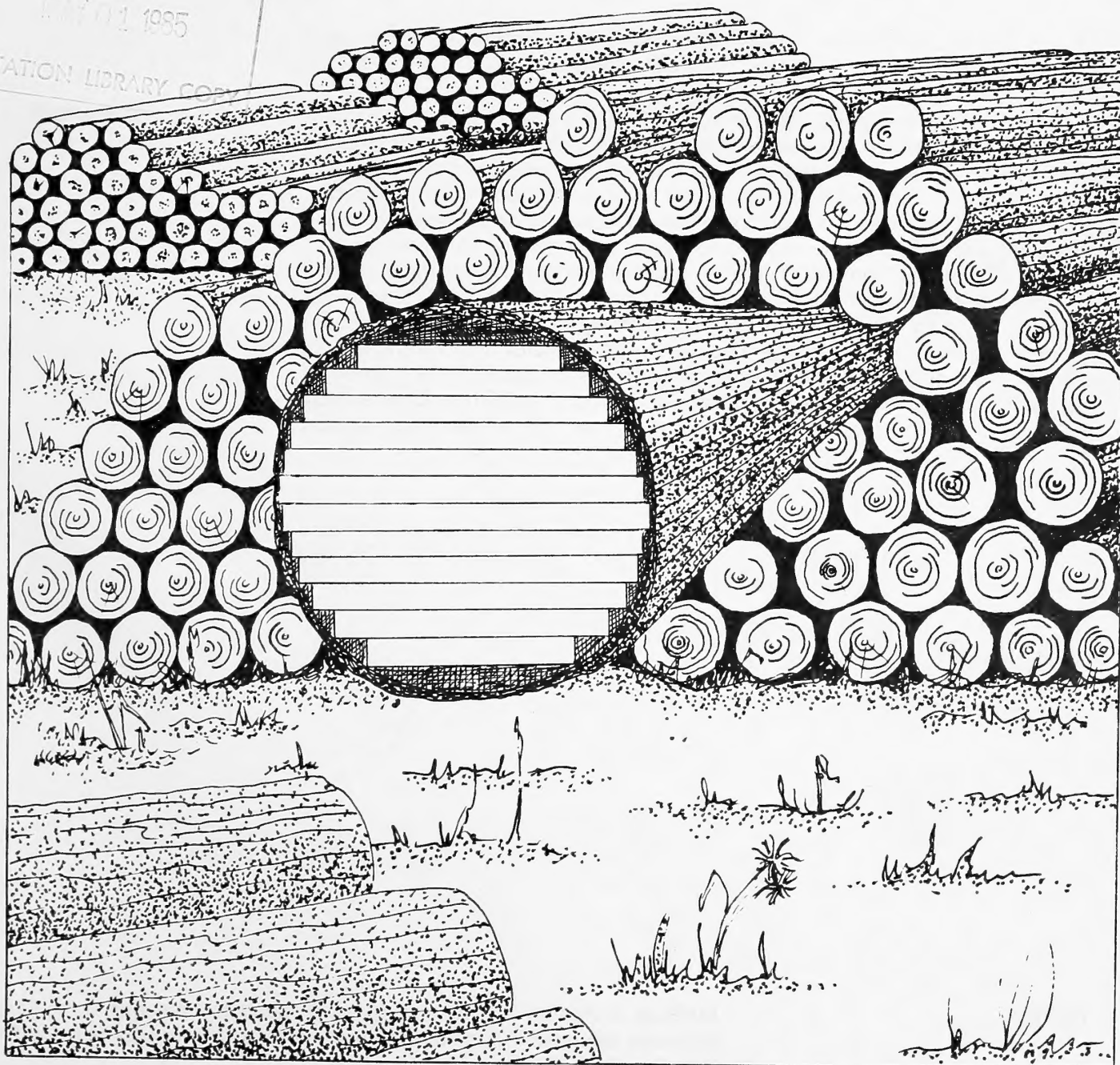
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Lumber Recovery From Ponderosa Pine in the Black Hills, South Dakota

Marlin E. Plank

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Abstract

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A sample of 400 ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees was selected from each of two sale areas in the Black Hills National Forest, South Dakota. The logs were processed through two sawmills into 1-inch-thick boards. Estimates of volume and value recovery based on cubic volume and board foot volume are shown in tables and figures.

Keywords: Lumber recovery, lumber yield, ponderosa pine (Black Hills), *Pinus ponderosa*, South Dakota (Black Hills).

Summary

A sample of 400 ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees was selected from two sale areas in the Black Hills National Forest, South Dakota. The logs were processed through two sawmills and the primary product was 1-inch boards. Although there were slight differences between the two mills for some response variables, the data were combined so that overall product recovery information could be presented for ponderosa pine in the Black Hills. Recovery estimates are shown in tables and figures for both Scribner log volume and cubic log volume. Analysis of the data for mill-length logs indicated that recovery percent (overrun) would range from 151 percent for 5-inch logs to 108 percent for 19-inch logs. Cubic volume recovery of rough-green lumber increased from 41 percent to 55 percent over that same range of diameters. Over half the lumber volume recovered was graded No. 3 Common. A section on application of study results is included.

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Introduction

Ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) is the predominant tree species on 1.3 million acres in the Black Hills of South Dakota. Sawtimber volume, which includes trees 9 inches in diameter at breast height (d.b.h.) and larger, totals about 4,483 million board feet. Because production of lumber is a major industry and contributes to the local economy, it is vital that the wood-using industries remain competitive with those producing alternative products. Full and efficient use of the resource is required to maintain this competitiveness, and to do so requires current information about the volumes and grades of lumber that can be produced.

The major objective of this study was to determine the lumber volume, value, and grade recovered from ponderosa pine sawtimber in the Black Hills. This research provides a basis for estimating the volume and grade recovery from similar logs. The information is useful to loggers, sawmill operators, lumber remanufacturers, timber growers, and forest administrators. It can be used for making log allocations and in improving mill design and processing decisions.

Methods

Sample Selection

About 200 trees were selected from each of two sale areas in the Black Hills National Forest. The two areas contained trees that were typical of those found in many areas within the Forest. All trees from one area went to one sawmill in eastern Wyoming (mill A); trees from the other area went to a sawmill in western South Dakota (mill B). Trees were selected by 2-inch diameter classes and an attempt was made to sample about the same number of trees in each class (table 1). D.b.h. of the trees ranged from 5 to 23 inches in each of the samples and there were at least nine trees in each 1-inch diameter class from 6 through 16 inches.

Tree quality in the Black Hills is considered to be consistent and low, thus logs are generally not graded. Trees in the southern portion of the National Forest may be of lower overall quality than are those in the north. The lack of convincing evidence of the difference in quality and practical considerations regarding harvesting limited sampling to the two sale areas in the north. No attempt was made to sample old growth and young growth separately; trees were selected exclusively by diameter.

Table 1—Number of ponderosa pine trees selected from two sample areas in the Black Hills

| D.b.h class | Number of trees | |
|----------------|--------------------|--------------------|
| | Area 1 (mill A) | Area 2 (mill B) |
| 5- 6 | 18 | 18 |
| 7- 8 | 36 | 42 |
| 9-10 | 34 | 36 |
| 11-12 | 31 | 37 |
| 13-14 | 26 | 26 |
| 15-16 | 22 | 27 |
| 17-18 | 15 | 4 |
| 19-20 | 9 | 4 |
| 21-22 | 5 | 2 |
| 23 | 4 | 2 |

Harvesting and Log Identification

Trees were felled and bucked in accordance with normal industry practice. In the Black Hills, it is common practice to haul logs on "self-loading" trucks, so those logs are often bucked into 16-foot or shorter lengths. Trees for mill B were bucked into short logs while logs for mill A ranged from 32 to 56 feet. Total length of each tree and length and diameter of each bucked log were recorded. Each log was identified by tree number and position of the log within the tree. This number was used to identify lumber items produced from specific logs.

Scaling

After the logs were delivered to the respective millyards, they were rolled out and scaled. Scribner scale was taken by USDA Forest Service check scalers according to National Forest Log Scaling Handbook rules (USDA Forest Service 1973). Cubic scale was taken in conformance with the draft cubic log scaling handbook.^{1/} The amount and reasons for each scale deduction were documented. Because logs delivered to mill B were already in milling lengths, no scale was taken on the log deck. Logs for mill A were bucked into milling lengths just prior to sawing and were scaled for Scribner volumes on the log deck. Average defect for Scribner volume in this sample was about 9 percent; sweep was the most common defect.

Lumber Manufacturing

Each mill was equipped with a circular head saw, a gang saw, edger, and a gang trimmer. In addition, mill A had a two-saw scragg fed by an end-dogging carriage and also had another small edger.

Logs were sawn to recover the usual lumber items produced by each mill. As logs entered the mill they were numbered sequentially. All the boards from a log were given the same number so that the recovery could be related back to the original log and tree. Only 1-inch boards were sawn with nearly all of the resulting lumber (97 percent) being in the Common grades.

All lumber was kiln-dried, planed, and graded. Grading was done by company graders under the supervision of a quality inspector from the Western Wood Products Association according to their grading rules (Western Wood Products Association 1977). Lumber was tallied in the surfaced dry condition, ready for shipment. Width of lumber ranged from 4 to 12 inches.

Analysis

The objective of this paper is to present overall product recovery information for ponderosa pine in the Black Hills. Analysis was therefore directed to (1) finding a suitable model for predicting lumber volume and value recovery, and (2) determining if lumber volume recovery was different for the two sample areas.

^{1/} Review draft (1978) of the cubic scaling handbook available from USDA Forest Service, Timber Management, P.O. Box 2417, Washington, D.C. 20013.

Dependent variables for volume recovery include cubic recovery percent (CR%), lumber recovery factor (LRF), and recovery percent (overrun).^{2/} For value, the variables include dollars per thousand board feet lumber tally (\$/MLT) and dollars per hundred cubic feet (\$/CCF) of log scale. Experience indicates that the relationship of product recovery to log diameter is best described by polynomial equations using diameter (D) and combinations of D^2 , $1/D$, and $1/D^2$ as independent variables. Models tested were:

$$\begin{aligned} y &= b_0 + b_1D, \\ y &= b_0 + b_1D^2, \\ y &= b_0 + b_1D + b_2D^2, \\ y &= b_0 + b_11/D, \\ y &= b_0 + b_11/D + b_21/D^2, \text{ and} \\ y &= b_0 + b_1D + b_21/D + b_31/D^2. \end{aligned}$$

Coefficient of determination and F value were the major criteria for selecting the best models. Statistical tests were made at ($P \leq 0.05$). Models selected for the appropriate dependent variable and the descriptive statistics are shown in the respective results section.

Differences in lumber recovery between the two areas were tested using CR% of rough-green lumber from mill-length logs. Cubic recovery percent of rough-green lumber, unlike overrun and LRF, reflects the actual volume of lumber recovered and is independent of lumber items sawn and the target sizes of each mill (Fahey and Snellgrove 1982). Covariance analysis was used to compare this recovery from the two mills. Although tests for a difference in slope or elevation between areas may have been significant, they were so low as not to be practically important when the γ_m (Draper and Smith 1981) criterion was applied. Because of this, *lumber volume recovery was combined for the two areas.*

Results and Discussion

Volume and value recovery relationships discussed in this section are for mill-length logs only. Relationships discussed under the sections regarding direct product estimates are for log lengths as delivered to the mill. In that section, separate relationships are shown depending on whether the logs were woods length or mill length.

^{2/}Terms are defined in the glossary.

Cubic Recovery Percent

Cubic recovery percent can be based on rough-green or surfaced-dry lumber. Both are related to diameter and are shown in table 2 and figure 1. The difference between the recovery of green and dry lumber is the volume lost because of shrinkage and planer shavings. The percentages of lumber, planer shavings, and sawdust increase slightly with increasing log diameter, while the percentage available for chips decreases. These recovery percents are based on the gross cubic foot (CF) volume of logs.

Table 2—Estimated percent of cubic volume for products manufactured from ponderosa pine logs in the Black Hills

| Scaling diameter | Lumber recovery factor | Rough-green lumber | Surfaced dry lumber | Shrinkage and planer shaving | Sawdust | Chippable volume |
|------------------|------------------------|--------------------|---------------------|------------------------------|---------|------------------|
| Inches | BF/CF | Percent | | | | |
| 5 | 4.6 | 41 | 25 | 16 | 9 | 50 |
| 6 | 4.6 | 41 | 25 | 16 | 9 | 50 |
| 7 | 4.7 | 43 | 26 | 17 | 9 | 48 |
| 8 | 4.9 | 44 | 28 | 16 | 9 | 47 |
| 9 | 5.1 | 46 | 29 | 17 | 10 | 44 |
| 10 | 5.3 | 47 | 30 | 17 | 10 | 43 |
| 11 | 5.5 | 49 | 31 | 18 | 10 | 41 |
| 12 | 5.6 | 50 | 32 | 18 | 10 | 40 |
| 13 | 5.8 | 51 | 33 | 18 | 10 | 39 |
| 14 | 5.9 | 52 | 34 | 18 | 10 | 38 |
| 15 | 6.0 | 53 | 35 | 18 | 11 | 36 |
| 16 | 6.1 | 53 | 35 | 18 | 11 | 36 |
| 17 | 6.2 | 54 | 36 | 18 | 11 | 35 |
| 18 | 6.3 | 55 | 37 | 18 | 11 | 34 |
| 19 | 6.4 | 55 | 37 | 18 | 11 | 34 |

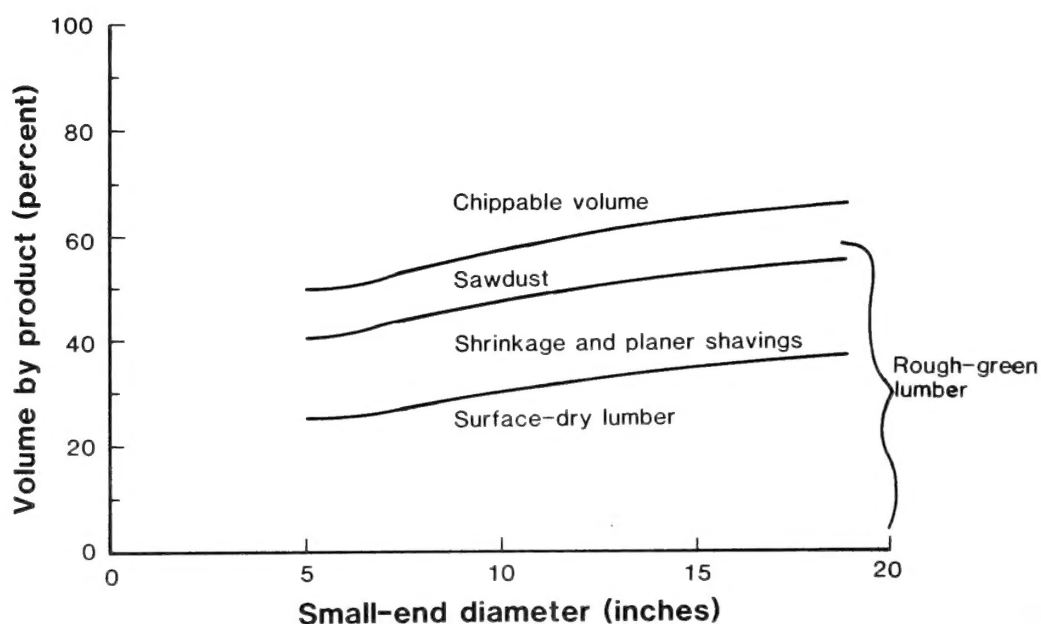


Figure 1.—Volume of products recovered expressed as a percentage of gross cubic foot volume of logs by diameter. This represents the combined recovery of mill-length logs from two sawmills cutting 1-inch-thick lumber.

Lumber Recovery Factor

The relationship between LRF and log diameter for data from both mills is shown in figure 2 and table 2. The trend is similar to that of CR% where there is a slight increase with increasing log diameter. Lumber recovery factor was 4.6 BF of lumber per CF of gross log volume for 5-inch diameter logs and gradually increased to 6.4 for 19-inch logs.

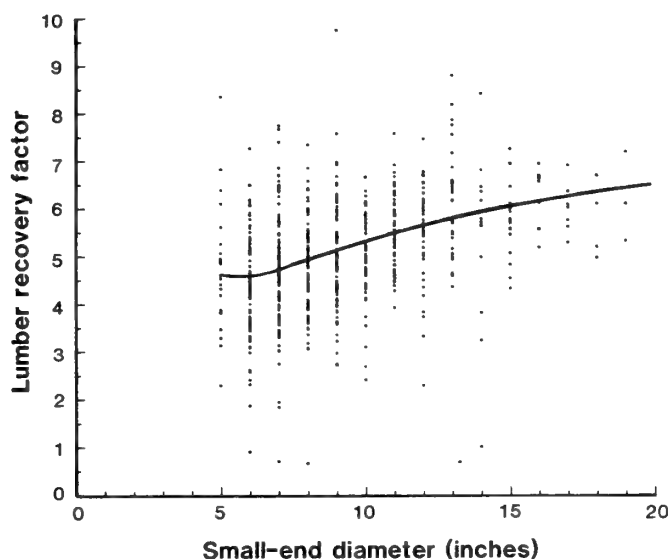


Figure 2.—Lumber recovery factor by scaling diameter for combined data from two sawmills. The recovery factor is for mill-length logs and is based on gross cubic foot volume of logs:

$$y = 8.25 - 40.89(1/d) + 113.57(1/d^2) .$$

Coefficient of determination = 0.160 and standard deviation from regression = 1.05.

Recovery Percent (Overrun)

Overrun is the common term used to describe the amount of lumber recovered that is in excess of the net log scale and is expressed as a percentage of the log scale. Recovery percent is often confused with overrun, but it is lumber tally divided by net log scale. A recovery percent of 150 would be equal to 50 percent overrun. Recovery percent is the term used in this report:

$$\text{Recovery percent} = \frac{\text{lumber tally}}{\text{net log scale}} \times 100 .$$

The relationship of recovery percent to diameter (based on Scribner board foot scale) is shown in table 3 and figure 3. The trend shows a steep decline from 151 percent at 5 inches to 117 percent at 12 inches, and falls gradually to 108 percent at 19 inches. This overall reduction of recovery percent with increasing log diameter is typical of mills that produce nominal 1-inch lumber. The statistical relationships between recovery percent and log diameter, although not strong, are significant. Estimates of recovery percent should be made by diameter class rather than by use of an average. Note that this study was not designed to replicate the same proportions of log diameters encountered in actual practice.

Table 3—Estimated recovery percent (overrun) from ponderosa pine logs in the Black Hills

| Scaling diameter | Number of logs | Net scale | Defect | Estimated recovery (overrun) |
|------------------|----------------|------------|---------|------------------------------|
| Inches | | Board feet | Percent | |
| 5 | 19 | 205 | 0 | 151 |
| 6 | 109 | 1475 | 14 | 142 |
| 7 | 125 | 2910 | 11 | 135 |
| 8 | 102 | 2460 | 10 | 130 |
| 9 | 93 | 3170 | 8 | 126 |
| 10 | 66 | 3080 | 10 | 122 |
| 11 | 66 | 3980 | 8 | 120 |
| 12 | 46 | 3310 | 6 | 117 |
| 13 | 33 | 2940 | 7 | 116 |
| 14 | 16 | 1520 | 16 | 114 |
| 15 | 16 | 2090 | 3 | 113 |
| 16 | 8 | 1130 | 8 | 111 |
| 17 | 5 | 800 | 9 | 110 |
| 18 | 6 | 1080 | 14 | 109 |
| 19 | 4 | 890 | 10 | 108 |

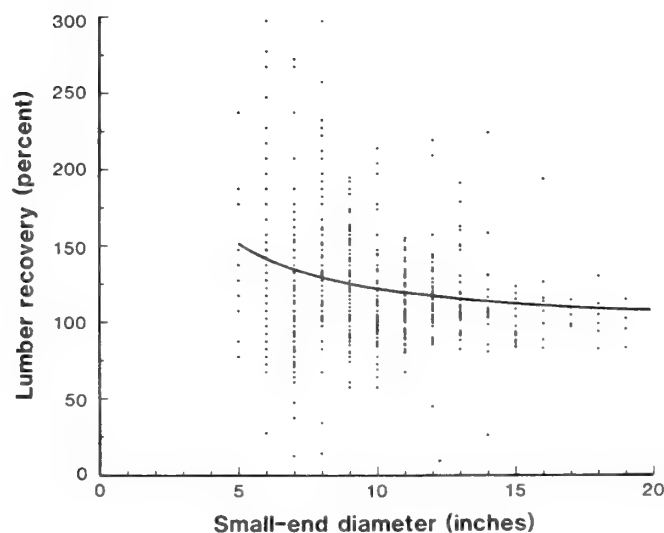


Figure 3.—Percent of lumber recovery (overrun) over scaling diameter. Data are combined recovery for mill-length logs from two sawmills cutting 1-inch-thick lumber:

$$y = 93.12 + 291.61(1/d)$$

Coefficient of determination = 0.052 and standard deviation from regression = 42.0.

Table 4—Estimated percent of volume in various lumber grades, by diameter class, for ponderosa pine logs in the Black Hills

| Diameter | Lumber grade | | | | |
|----------|---------------------|------------------|----------|----------|----------|
| | Molding and Selects | 2 and BTR Common | 3 Common | 4 Common | 5 Common |
| Inches | Percent | | | | |
| 5 | | 12 | 49 | 22 | 17 |
| 6 | 1 | 19 | 54 | 18 | 8 |
| 7 | 1 | 19 | 59 | 17 | 4 |
| 8 | 1 | 19 | 59 | 18 | 3 |
| 9 | 2 | 14 | 62 | 19 | 2 |
| 10 | 3 | 10 | 64 | 21 | 2 |
| 11 | 3 | 8 | 65 | 22 | 2 |
| 12 | 4 | 6 | 64 | 23 | 3 |
| 13 | 5 | 5 | 62 | 24 | 4 |
| 14 | 5 | 4 | 59 | 27 | 5 |
| 15 | 6 | 4 | 55 | 29 | 6 |
| 16 | 7 | 4 | 53 | 30 | 6 |
| 17 | 7 | 4 | 51 | 32 | 6 |
| 18 | 8 | 3 | 47 | 37 | 5 |
| 19 | 6 | 3 | 40 | 48 | 3 |

Lumber Grade

Most sawmills in the Black Hills that cut 1-inch boards produce a high proportion of Common grades of lumber; this study was no different. The greatest proportion of volume was in No. 3 Common with lesser amounts in the other Common grades. Mill A produced about 5 percent of the volume in Moulding and Selects; mill B obtained only slightly more than 1 percent in Selects and did not cut Moulding. Table 4 shows the estimated recovery percent of each lumber grade, by 1-inch diameter class, for both mills combined.

Approximate percentage of total volume recovered for various lumber grades in earlier studies (Landt and Woodfin 1959, Mueller and Kovner 1967) is shown in table 5. There was little difference in average recovery of No. 4 and No. 5 Common among all studies. The current study produced a higher proportion of No. 3 Common over the same range of diameters than did previous studies. One study had an average log diameter of about 11 inches; the average for the current study was about 9 inches. On the average, logs from the previous studies came from larger trees and this is probably the reason for the higher quality of lumber in those studies.

Table 5—Percent of total volume recovered, by lumber grade, for two previous ponderosa pine studies in the Black Hills

| Grade | Average volume recovered (percent) | |
|------------------|------------------------------------|--------------------------|
| | 1959 study ^{1/} | 1967 study ^{2/} |
| Shop and Better | 10 | 15 |
| 2 and BTR Common | 21 | 25 |
| 3 Common | 35 | 33 |
| 4 Common | 29 | 25 |
| 5 Common | 5 | 2 |

^{1/}Landt and Woodfin 1959.

^{2/}Mueller and Kovner 1967.

Table 6—1978 lumber prices for White Woods^{1/} in the Black Hills

| Item | Lumber grade | | | | | | |
|-------------------------|----------------|----------|----------|----------------|----------|----------|----------|
| | C & BTR Select | D Select | Moulding | 2 & BTR Common | 3 Common | 4 Common | 5 Common |
| ----- Dollars/MLT ----- | | | | | | | |
| 1 x 4 | 732 | 495 | 444 | 330 | 168 | 126 | 97 |
| 1 x 6 | 888 | 602 | 444 | 333 | 200 | 143 | 97 |
| 1 x 8 | 824 | 576 | 444 | 316 | 202 | 156 | 97 |
| 1 x 10 | 894 | 592 | 444 | 288 | 201 | 179 | 97 |
| 1 x 12 | 1047 | 834 | 444 | 344 | 243 | 188 | 97 |

^{1/}White Woods are Engelmann spruce, any true firs, any hemlocks, and any pines.

Value

Lumber.—Lumber value is determined by applying an appropriate price to the volume by grades for various items of lumber produced from a log. Prices used in this study are shown in table 6. The total value of the lumber items divided by the total volume of those items (\$/MLT) is a useful indication of log quality. The relationship of \$/MLT to log diameter is shown in figure 4. There is only a slight increase in value with increasing diameter because the quality of lumber recovered from this resource did not change greatly over the limited range of diameters. There was a large amount of variation around the mean of each diameter that could not be explained by the model. The relationship is significant but practicality should dictate whether to use lumber values based on diameter rather than an average.

Log.—Dollars per hundred cubic feet of log volume (\$/CCF) is the value of lumber from a log divided by the cubic volume of that log. It expresses the combination of average value of the lumber (\$/MLT) and the percentage of cubic volume recovered. The relationship of \$/CCF to diameter is shown in figure 5 for all data combined. As expected, the value increased with increasing diameter because CR% and \$/MLT both increased with diameter.

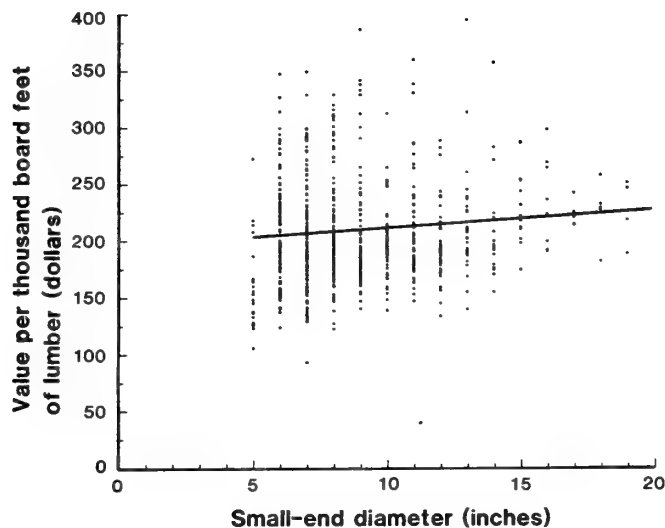


Figure 4.—Dollars per thousand board feet (\$/MLT) of lumber tally, by scaling diameter, for both mills. This curve follows the general trend expected—value increasing with diameter. The limited size of the trees in the Black Hills, however, precludes the high value often obtained from ponderosa pine in areas where larger trees are prevalent:

$$y = 195.46 + 1.61(d)$$

Coefficient of determination = 0.010 and standard deviation from regression = 45.78.

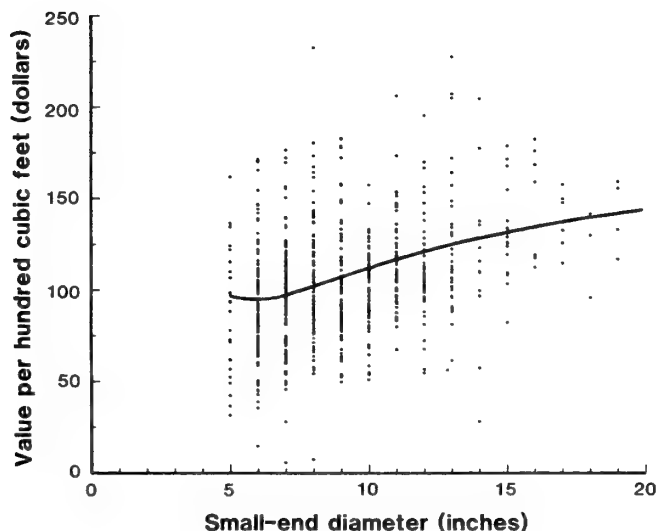


Figure 5.—Dollars per hundred cubic feet (\$/CCF), by scaling diameter, for data combined from both mills. Cubic recovery percent and the average value of the lumber both increased with diameter; consequently, the \$/CCF follows the same trend:

$$y = 193.03 - 1144.49(1/d) + 3325.14(1/d^2)$$

Coefficient of determination = 0.125 and standard deviation from regression = 30.93.

Estimating Products

Volume and value of products can be predicted directly from cubic log scale. Cubic scale provides a less variable and more accurate estimate of volume than Scribner scale (Fahey and others 1981); it is, therefore, a better predictor of products. The relationships of product volume to scale volume in this section are compared for the two mills and are based on cubic product scale.^{3/} The logs were scaled in the lengths delivered to the mills. Logs for mill A were scaled in the long log or tree length form and those for mill B were scaled as mill-length logs. The relationship of total lumber tally, chippable material, and sawdust to log volume is shown in figure 6. Figure 7 shows the relationship for value. There is a strong correlation between both volume and value of products and cubic log volume as evidenced by the R^2 statistic on each figure.

Comparison of Mill A and Mill B

The primary objective of this paper is to determine the overall volume and lumber grade recovery from ponderosa pine in the Black Hills, but it became apparent during the analysis that there were some differences in the recovery data obtained at each mill. The objective of this section is to examine the differences in volume recovery between the two mills and explain why these differences occurred.

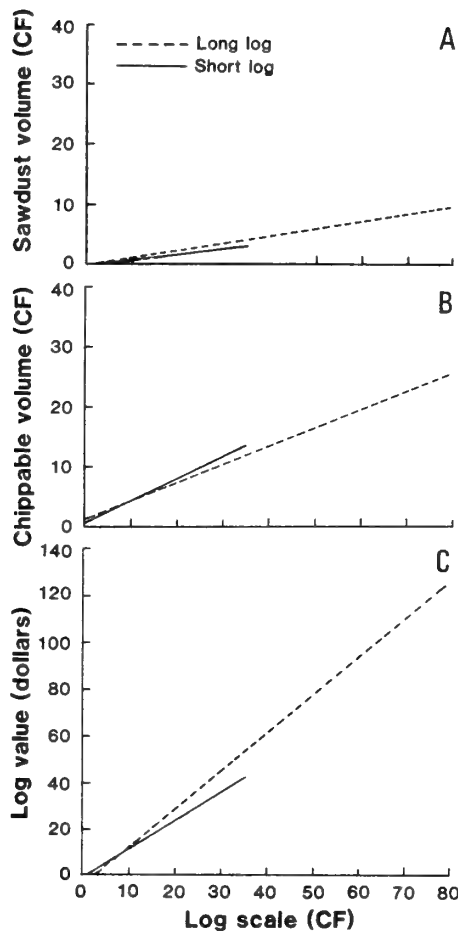
Although the equipment in the two mills was similar, the conversion efficiency and lumber items produced were different (table 7). Actual thickness of nominal 1-inch rough-green lumber at mill A was 32/32-inch and at mill B it was 35/32-inch, therefore, mill A would be expected to attain a higher recovery of volume. Evidence of this would be reflected predominantly in LRF and overrun. Cubic recovery based on rough-green lumber dimensions does not vary significantly for any mill that produces similar items with similar equipment.

The average LRF was 5.3 for mill A and 5.0 for mill B. Because mill B cut thicker green sizes, it lost more to planer shavings than did mill A. For each 1,000 CF of log volume, mill A recovered an average of 5,300 BF of surfaced dry lumber but mill B only recovered 5,000 BF. Overrun followed the same trend.

^{3/}Cubic product scale is gross cubic scale adjusted for all defects expected to affect the yield of solid wood products.

Table 7—Lumber yield in percent of total lumber tally for sizes of ponderosa pine boards cut from two mills in the Black Hills

| Lumber size | Average board foot volume | |
|-------------|---------------------------|--------|
| | Mill A | Mill B |
| | - - - - Percent - - - - | |
| 1 x 4 | 16 | 25 |
| 1 x 6 | 25 | 34 |
| 1 x 8 | 25 | 20 |
| 1 x 10 | 17 | 12 |
| 1 x 12 | 16 | 9 |



A

Figure 6.—Rough-green lumber volume, chippable volume, and sawdust volume, by cubic log scale, for ponderosa pine in the Black Hills. Cubic product scale is the basis for log volume: It is gross cubic scale reduced for all defects expected to affect the yield of solid wood products.

A. Long log (mill A):

$$y = -0.064 + 0.120(\text{ft}^3) .$$

Coefficient of determination = 0.94 and standard deviation from regression = 0.39.

Short log (mill B):

$$y = -0.392 + 0.102(\text{ft}^3) .$$

Coefficient of determination = 0.94 and standard deviation from regression = 0.14.

B. Long log (mill A):

$$y = 1.179 + 0.304(\text{ft}^3) .$$

Coefficient of determination = 0.71 and standard deviation from regression = 2.57.

Short log (mill B):

$$y = 0.696 + 0.362(\text{ft}^3) .$$

Coefficient of determination = 0.83 and standard deviation from regression = 0.84.

C. Long log (mill A):

$$y = -8.27 + 6.88(\text{ft}^3) .$$

Coefficient of determination = 0.94 and standard deviation from regression = 21.67.

Short log (mill B):

$$y = -6.51 + 5.96(\text{ft}^3) .$$

Coefficient of determination = 0.94 and standard deviation from regression = 7.89.

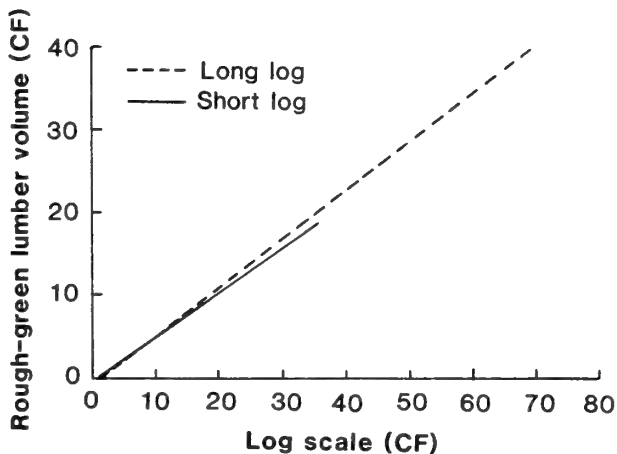


Figure 7.—Total lumber value of logs by cubic product scale for ponderosa pine in the Black Hills. Long log (mill A):

$$y = -4.63 + 1.65(\text{ft}^3) .$$

Coefficient of determination = 0.91 and standard deviation from regression = 6.76.

Short log (mill B):

$$y = -1.01 + 1.23(\text{ft}^3) .$$

Coefficient of determination = 0.87 and standard deviation from regression = 2.48.

Application Repricing

Values of lumber were based on 1978 prices for White Woods^{4/} in the Black Hills and were furnished by the Rocky Mountain Region, USDA Forest Service. To adjust to current prices, simply multiply the predicted average value (that is, \$/CCF or \$/MLT) by the ratio of the new price of 1x6 No. 3 Common to the price of 1x6 No. 3 Common in this report (\$200). For example, if the previous value of a 10-inch log was \$198.33/MLT and the new value of 1x6 No. 3 Common was \$250/MLT, then \$198.33 multiplied by $(\$250/\$200)$ gives a value of $\$198.33 \times 1.25$, or \$247.91.

Predicting Timber Value

A common use of the information in the report is to estimate the value of a stand of timber; for example, a tract of timber is offered for sale that contains 1 million BF or 200,000 CF. Typically, the number of logs and volume by diameter class within a log grade would be provided from a cruise. In this example I will use a 10-inch diameter class and assume that all logs are the same grade. This diameter class contains 2,552 logs with a volume of 100,000 BF or 23,080 CF.

Overrun.—The estimated lumber recovery percent for a 10-inch log would be 122 (from table 3); therefore $(100,000 \text{ BF}) (1.22) = 122,000 \text{ BF}$ of lumber. Using the equation in figure 3, the value of the 10-inch logs is:

$$\begin{aligned}\$/\text{MLT} &= 195.46 + 1.61(10) = \$211.56; \text{ and} \\ \text{total lumber value} &= \$211.56/\text{MLT} (122 \text{ MBF}) = \$25,810.32.\end{aligned}$$

This procedure could be used for each diameter class and the sum of the diameter class values would equal the total value of lumber for the stand.

Cubic recovery percent.—To calculate the total value of the 10-inch logs on a CF basis, use the equation in figure 5. The calculation would be:

$$\begin{aligned}\$/\text{CCF} &= 193.03 - 1144.49(1/10) + 3325.14(1/10^2) = \$111.83 \text{ CCF}; \text{ and} \\ \text{total value} &= 111.83/\text{CCF} (230.80 \text{ CCF}) = \$25,810.36.\end{aligned}$$

This procedure would also be done for each diameter class to obtain lumber value for the stand.

Direct Estimators.—With this method the value can be determined directly from log volume. Using the equation for the relationship shown in figure 7, the calculation would be:

$$\begin{aligned}\text{lumber value} &= -1.01(\text{no. of logs}) + 1.23(\text{CF}), \text{ or} \\ \text{lumber value} &= -1.01(2,552) + 1.23(23,080) = \$25,810.88.\end{aligned}$$

Value of secondary products.—Secondary products such as chips or sawdust cannot be measured in BF but are often measured in CF or by weight. Estimating products directly from scale volume makes it easy to calculate chip and sawdust

^{4/}White Woods are Engelmann spruce, any true firs, any hemlocks, and any pines.

volumes. With these volumes it is possible to calculate the value of these products. For instance, the volume of chips for the 10-inch diameter class (2,552 logs) can be calculated using the proper equation from figure 6:

$$\text{chip volume} = 0.696(2,552) + 0.362(23,080 \text{ CF}) = 10,130 \text{ CF (rounded)}.$$

If the price of chips were \$60 per oven-dry ton or \$0.03 per pound and the density were 24 pounds per CF,^{5/} there would be 243,120 pounds ((10,130 CF) (24 lb/CF)) of chippable fiber with a value of \$7,293.60 ((243,120 lb) (\$0.03/lb)). The value of the chips could be added to the value of the lumber and would result in a more accurate estimate of the total value of the 10-inch logs. The same procedure could be used to obtain a value for sawdust.

Information in this report could also be used to estimate the volume, by lumber grade, that could be produced from a group of logs. Suppose that in a deck of logs, there were 50,000 BF of 12-inch logs. Use table 3 to find the estimated recovery percent for 12-inch logs and multiply that percentage by the net log scale to find the estimated volume of lumber:

$$\text{lumber volume} = 50,000 (1.17) = 58,500 \text{ BF}.$$

The final step is to multiply this lumber volume by the percent recovery expected for each lumber grade (table 4):

| | |
|----------------------|---------------------------|
| Molding and Selects | 58,500 (0.04) = 2,340 BF |
| No. 2 and BTR Common | 58,500 (0.06) = 3,510 BF |
| No. 3 Common | 58,500 (0.64) = 37,440 BF |
| No. 4 Common | 58,500 (0.23) = 13,455 BF |
| No. 5 Common | 58,500 (0.03) = 1,755 BF |

With volumes of lumber established for each lumber grade, the value can be determined by applying appropriate prices to these volumes. This procedure can be extended to include all diameter classes in the inventory. With this information a mill manager can select the log mix needed to fill particular orders and at the same time regulate the inventory.

Conversion Factors

It is often desirable to have log volumes estimated in cubic units. Cahill (in press) developed equations to convert Scribner board foot volume to cubic volume. The appropriate equation was tested on mill-length logs from one of the sale areas selected for this study. The estimate of the gross volume was the same as the actual gross volume; the product cubic volume was 2 percent higher. From this test it appears that Cahill's equation can be used to convert Scribner volume to cubic volume when applied to mill-length logs.

Metric Equivalents

1 inch = 2.54 centimeters
 1 foot = 0.3048 meter
 1 cubic foot = 0.02832 cubic meter
 1 pound = 453.6 grams

^{5/} Oven dry weight per unit of green volume (Forest Products Laboratory 1974).

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Glossary

Cubic recovery percent (CR %)—the cubic feet of lumber produced from a cubic foot of log input. Log volume can be expressed as a percentage of the gross, net (firmwood), or product (merchantable) cubic scale. Cubic recovery percent can be based on surfaced-dry as well as rough-green lumber.

Lumber recovery factor (LRF)—the board feet of lumber produced from a cubic foot of log input. As with cubic recovery percent, log input volume can be gross, net (firmwood), or product (merchantable) cubic scale.

Recovery percent (overrun)—the board feet of lumber produced from a board foot of net log scale expressed as a percentage. It is equal to overrun plus 100 percent. Although recovery percent has traditionally been expressed as a percentage of net Scribner scale, it can also be expressed as a percentage of gross Scribner scale.

Dollars per thousand board feet lumber tally (\$/MLT)—the average value of the lumber produced, based on the lumber produced and the pricing structure used in this paper.

Dollars per hundred cubic feet of log scale (\$/CCF)—the total value of the lumber produced from a log divided by the cubic scale of the log. Cubic scale volume may be gross, net (firmwood), or product (merchantable).

Plank, Marlin E. Lumber recovery from ponderosa pine in the Black Hills, South Dakota. Res. Pap. PNW-328. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. **1985.** 14 p.

A sample of 400 ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees was selected from each of two sale areas in the Black Hills National Forest, South Dakota. The logs were processed through two sawmills into 1-inch-thick boards. Estimates of volume and value recovery based on cubic volume and board foot volume are shown in tables and figures.

Keywords: Lumber recovery, lumber yield, ponderosa pine (Black Hills), *Pinus ponderosa*, South Dakota (Black Hills).

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